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APPLICATION FOR PATENT

COMBINATION SWITCH AND ROUTING-SWITCHING RADIO BASE STATION

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Patent Application
Docket #34648-00437USPT
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COMBINATION SWITCH AND ROUTING-SWITCHING RADIO BASE STATION

REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of priority from copending U.S. Provisional Application for Patent No. 60/177,805 titled "IP Packet Router Integrated into a Radio Base Station" filed on January 25, 2000, is related thereto, is commonly assigned therewith, and the subject matter thereof is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

Technical Field of the Invention

The present invention relates in general to the telecommunications field and, in particular, to an apparatus providing both circuit-switched and packet-switched communications within a telecommunications network.

Description of Related Art

Radio base stations (RBSs) within a mobile telephony system are often used as

network traffic transmission transfer points to other base stations. Commonly used network topologies for connecting such base stations to each other include the chain, ring, and tree topologies. A single transmission link typically operates at rates of 2, 4, or 8 Mbit/second, which is greater than what is used by a single base station. Therefore, multiple base stations often use a single transmission link. Since the physical transmission medium is usually a radio link, base station sites often house radio link equipment as well.

Each base station is typically connected to the transmission network with one or more physical transmission links. The number of links depends on the desired network topology, requirements for redundancy, and the need for transmission capacity at the base station. In a circuit-switched network **9**, an internal switch matrix is used to distribute fractions of connected bandwidth transmissions within the base station to various transceivers and other signaling devices. The built-in switch matrix is sometimes also used for switching excess bandwidth to another link in the transmission network. This link is then used for connection to other base stations. As shown in the prior art network block diagram of Figure 1A, a string of cascaded Internet nodes **20** and radio base stations **30** are connected via network ports **32** within a network **10**, such as a combination Internet Protocol (IP) network **8** and a switching network **9**. In the network **10** topology shown in Figure 1, circuit-switched (STM)

RBSs **30** are connected to Internet nodes **20**. This type of mixed network **10** is a common migration scenario as users migrate from a completely circuit-switched network to an IP network. However, the flexibility provided by packet switched connections and the IP Suite in combination with circuit-switched networks requires a change in switching technology. A converter **80** may be needed to convert signals between the circuit-switched network **9** and the IP network **8**.

Each RBS **30** is typically controlled by a Base Station Controller (BSC) **40**, and is connected to the controller **40** using a control/traffic port **31**. For example, the BSC **40** keeps track of resources within the STM RBS **30**. Such resources include the number and type of radio transceivers, and the number and type of internal switching connections. The connections within the switch **50** are known as "circuit-switched connections." The switch **50** setup (i.e., how time slots within a time frame **72** are switched) is accomplished using the BSC **40**. Thus, it is the job of the BSC **40** to track resources within the base station, which include transceivers **60, 61** and connections within the switch **50**. Once the connections within the switch **50** are set, they are usually not changed unless there is a disturbance within the transmission network **10** or the STM RBS **30** is shut down. The BSC **40** is also the source/destination for connections to from the RBS **30**.

The transmission interface, such as a 2 Mbit/sec G.703 interface, delivers data in 32 byte frames **72**, typically divided into one byte time slots **74.** The switch **50** switches all time slots that have the same position in the frame **72** to one internal destination. For example, considering the circuit-switched transceivers **60, 61**, the switch **50** may elect to send time slots #4 and #5, **76**, **78,** in each frame **72** to the transceiver **61** via internal interface connection **70**.

The typical messages which are used to load IP networks include e-mail, file transfer, and accesses to the world-wide web. The length of these messages, which are divided into packets **82**, is often a few hundred bytes, on up to a thousand or more bytes. For mobile radio systems, on the other hand, speech packets are typically used to load the network. These packets are quite small (i.e., on the order of 40-60 bytes) but are transmitted rapidly (i.e., about every 20 milliseconds. This disparity in packet size and frequency of transmission influences the optimal design and routing elements within a mixed network **10**.

IP packets **82** from the nodes **20** can only be inserted into available time slots within the frames **72**, which may require the use of a converter **80**. Thus, IP-formatted information (i.e., packets **82)** can be sent to the BSC **40** without changing the operational characteristics of the switch **50**. In this way, IP-formatted data can be switched without routing, which is

inefficient.

As mentioned previously, the current solution is to divide the available bandwidth into small selected portions (i.e., one or more time slots) and assign them to each base station. However, when packet transmissions are used within the mixed network **10**, it is inefficient to divide the link bandwidth into fractions (i.e., one or more consecutive time slots) reserved to different base stations **30**. The bandwidth for each device or base station is thus reserved, and cannot be reused by other devices. Thus, the transfer time for individual packets will be fairly long if only a few time slots are used.

Thus, in mixed networks **10**, there is a need for efficient data distribution between RBSs **30** and the BSC **40**. This need is independent of the transmission network used. For migration from a circuit-switched network **9** to an IP network **8**, it should also be possible to mix IP routing and STM switching.

A related problem is illustrated in prior art figure 1B. Sending packet data **82** in an all-IP network **12** using conventional RBSs **30** requires an additional router **65**, which adds cost and requires space. Thus, a solution which obviates the need for the router **65** to communicate packet data to RBSs **30** in an all-IP network **12** is also needed.

SUMMARY OF THE INVENTION

In accord with one embodiment of the present invention, a combination switch includes a time slot switch and a router. The combination switch is in electronic communication with the telecommunications network providing frames of circuit-switched data and packets of IP data, such that the time slot switch receives the circuit-switched data, and the router receives the IP data. The router is in electronic communication with the time slot switch.

The combination switch may include one or more central processing units and one or more digital signal processors. Typically, the central processing unit communicates with the time slot switch and the router while executing one or more network management protocols, such as the Simple Network Management Protocol (SNMP). Typically, a digital signal processor is used to implement the time slot switch, and another digital signal processor is used to implement the router.

In another embodiment, the invention includes a routing-switching base station, which may be a radio base station, having a combination time slot switch and Internet Protocol switch (or separate time slot switch and router elements), in electronic communication with a plurality of transceivers. The base station is in electronic communication with a

telecommunications network providing frames of circuit-switched data and packets of IP data. The combination switch receives the data, and sends it on to the plurality of transceivers.

In an alternative embodiment, a routing radio base station of the present invention includes a router for receiving one or more packets of IP data from the network, along with a plurality of transceivers which are in electronic communication with the router. As the combination routing-switching base station migration solution is incorporated into networks over time, the need for the router and time slot switch combination is expected to give way to the router radio base station incorporating only the router.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the method and apparatus of the present invention may be had by reference to the following detailed description when taken in conjunction with the accompanying drawings wherein:

FIGURES 1A and 1B, previously described, are prior art block diagrams of a mixed network and all-IP network, respectively;

FIGURES 2A and 2B are block diagrams of the routing-switching base station and the routing radio base station, respectively, of the present invention; and

FIGURE 3 is a schematic block diagram of the combination switch of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

The preferred embodiment of the present invention and its advantages are best understood by referring to Figures 1-3 of the drawings, like numerals being used for like and corresponding parts of the various drawings.

Turning now to Figure 2A, the routing-switching base station **100** of the present invention can be seen. Included within the base station **100**, which may be a radio base station, is a combination time slot switch and Internet Protocol switch **110**, which may comprise a time slot switch **130** and a router **140**. Through a series of internal interface connections **70**, the combination switch **110** is placed into electronic communication with a plurality of transceivers **60, 90**. The transceivers may be radio frequency transceivers, optical transceivers, or other transceivers which operate using electromagnetic energy to communicate information. Thus, when a network supplies frames **72** of circuit-switched data to the base station **100**, they may be received by the combination switch **110**, and selected portions of the frames **72** can be sent on to the transceivers **60**. Similarly, when packets **82**

are received from the network, the IP data packets **82** can be sent on to the transceivers **90**. The transceivers **60, 90** may be similar or identical. The numeric differentiation is (only) used to show that either transceiver **60, 90** may be used to send/receive frames **72** or selected packets **82** of data.

The combination switch **110** (or the individual elements of a time slot switch **130** and a router **140**) located in the routing-switching base station **100** is a network migration solution that lends itself to use in mixed networks having a combination of legacy equipment that operates only with circuit-switched data, and newer equipment that operates using packet-switched data. However, as time goes on, and the use of antiquated circuit-switched equipment disappears, the routing-switching base station **100**, which may be a radio base station, will not require circuit switching functionality. The resulting routing radio base station **100'** will include the router **140** and one or more transceivers **90** in electronic communication with the router **140**, but not a time slot switch **130**. This solution, shown in Fig. 2B, solves the problem shown in Fig. 1B, wherein an extra router **65** is needed to interface conventional RBSs **30** to the all-IP network **12**. In the invention, the equivalent of router **65**, i.e., router **140**, is now included within the routing radio base station **100'**.

Thus, a cost efficient solution is provided by the present invention to replace the

built-in switch matrix **50** of prior art base stations **30**. The new (replacement) combination switch **110** is capable of acting as a packet router, as a circuit switch, or as a device which can provide packet-switching and circuit-switching at the same time. The integrated device (i.e., switch) **110** is able to terminate traffic bound for the base station **100**, to forward traffic bound for other base stations, and to distribute traffic internally within the base station **100**. The router **140** within the switch **110** is programmed to understand and implement the IP Suite.

The switch **110** (or the router **140** alone) can be implemented using various logical building elements, and is not meant to be limited by the exemplary illustrations given herein. For example, as shown in Figure 3, the switch **110** can be implemented using a central processing unit **260** and one or more digital signal processing units **200**. Using such a combination of logical building elements provides several advantages. Central processing units have a flexible construction set and can address large amounts of memory. Thus, such central processing units are suitable to process programs that are not time critical, and require complex instruction sets. These units are relatively inexpensive, and it is possible to combine multiple central processing units in a cluster to achieve higher data processing rates.

On the other hand, Digital Signal Processors (DSPs) typically have a specialized

instruction set, and access less memory than that which can be accessed by a central processing unit. Thus, DSPs are suitable to process programs that are time critical, and require relatively unsophisticated program instructions. DSPs can also be clustered to provide increased throughput.

The various elements of the combination switch **110** can be grouped into integrated circuits, such as a first integrated circuit **250**, a second integrated circuit **260**, and a third integrated circuit **270**. Thus, in the exemplary implementation of the combination switch **110** shown in Figure 3, the first integrated circuit **250** may contain three DSPs **200** communicating with two memories **210**, an external interface **230**, and an internal interface **240** using a common internal bus **255.** The bus **255** is also connected to the central processing unit **220**, located on the second integrated circuit **260.** The memory **210** within the third integrated circuit **270** is also connected to the bus **255**. Of course integrated circuits **250, 260** and **270** can all be further integrated into a single circuit (not shown).

In the combination switch **110** configuration shown in Figure 3, the circuitry within the second integrated circuit **260** (i.e., the central processing unit **220**) can communicate using Direct Memory Access (DMA) with the DSPs **200** and the memories **210** located in the first integrated circuit **250.** Another bus (not shown in Figure 3) may be used for DSP **200**

instruction fetches from the memories **210**, or other memories (not shown). The integrated circuit **250** may also contain special hardware and/or firmware for High-level Data Link Control (HDLC) protocol conversion. In the exemplary configuration of Figure 3, the time slot switch **130** may be implemented using the interfaces **230**, **240**, the memories **210**, and programs in two of the three DSPs **200.** The remaining DSP **200** (and excess capacity of the other DSPs **200**) and the central processing unit **220** and the DSPs **200** are used to execute the IP Instruction Suite. Some of the routines needed for transferring a message through the combination switch **110**, and executed within the DSPs **200**, might include HDLC controls, Point-to-Point Protocol (PPP), Link Control Protocol/Neighbor Discovery Protocol (LCP/NDP) for initiating PPP, multilink PPP, header compression, queuing (e.g., quality of service) and policing algorithms, packet forwarding IP, and the User Datagram Protocol (UDP). Typically, the memory **210** necessary for storing programs executed in the DSPs **200**, along with the memory **210** needed for a data storage, will be a few hundred kilobytes. The DSPs should operate at a program execution speed of approximately one billion instructions per second (i.e., 1,000 Mips).

In the central processing unit **220**, several protocols are required for setup, supervision, exception handling, etc. These include: IP Options Part, IP fragmentation, Open

Shortest Path First (OSPF) routing protocol, and the Simple Network Management Protocol (SNMP). The memory **210** required by the central processing unit **220** should be on the order of several megabytes. The operating speed of the central processing unit will typically be about several million instructions per second (e.g., 1-10 Mips).

The routing-switching base station **100**, the routing radio base station **100'**, and the combination switch **110** allow implementation of inexpensive router functionality in the place of conventional radio base stations, which contain only circuit-switching operational elements. Such an implementation allows use of the combination switch as a general IP packet router at little or no additional cost.

The combination switch **110** can be used as an internal packet switch so that packets from different devices can share the entire bandwidth allowed. Thus, the combination switch **110** can use a portion of the bandwidth for the base station **100** for circuit switched data **72**, and another portion of the bandwidth for packet-switched data **82**. Using an internal router **140** for switching will provide faster packet transfer speeds and shorter queuing delays for high priority packets when priority mechanisms are used.

The combination switch **110** configuration also allows internal devices, such as transceivers **60, 90**, to be addressed as IP nodes, and if desired, to be visible to the external network **10**. Using a router **140** as an internal switching device operating under the IP Suite means that special, non-standard protocols, will not be needed to operate the switch **110**.

Additional advantages of the switch **110** include automatic routing updates when the surrounding network **10** is changed (e.g., using the OSPF protocol); increased possibilities for plug-and-play base stations connected to a routing-switching base station **100**; standardized supervision methods, operation, and maintenance (e.g., using the SNMP protocol); and standardized methods for verifying quality of service, policing, and resource allocation.

During migration operations, there will be the opportunity for connecting routing-switching base stations where circuit-switch connections are required. As noted above, in this case, circuit-switched data can use some fraction of the bandwidth, while IP routed data can use the remaining fraction of the bandwidth. Conversion routines from the IP and circuit-switch formats can be implemented using the combination switch **110** for direct interfacing to transceivers **60, 90**. The functionality of the switch **110**, implemented as described above, can now be changed using software so that the switch **110** can act as a time

slot switch **130** alone, a combination switch **130,** or a router **140** alone, and manual visits to the site of the switch **110** to change its function are obviated. Also, as noted above, the routing radio base station **100'** (see Fig. 2B) may only require the presence of a router **140** and transceivers **90** when circuit-switched data is no longer present in the network **10**.

Finally, the DSPs **200** can operate as high performance packet switches, or as high performance circuit-switches. Circuit-switching and packet-switching can also be accomplished simultaneously. The same DSP **200** can perform internal distribution of data to various transceivers **60, 90** and other signaling devices. The DSPs **200** can also be assigned responsibility for internal data conversion (i.e., from circuit-switching protocols to IP, and vice versa). The DSPs **200** can also handle data routing and buffering, and administer Quality-of-Service functions within the IP Suite. The router **140** can also be used to concentrate several links that are lightly loaded into a single link for better utilization of available bandwidth.

Although a preferred embodiment of the method and apparatus of the present

invention has been illustrated in the accompanying drawings and described in the foregoing detailed description, it will be understood that the invention is not limited to the embodiment disclosed, but is capable of numerous rearrangements, modifications and substitutions without departing from the scope of the invention as set forth and defined by the following claims.